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Future Combat Systems —

New technologies foundation for more lethal force

By C. Sue Randles

Carolyn Sue Randles has more than 20 years of experience in acquisition. She served as the deputy director for the Joint Missile Alert Broadcast System in the OSD Joint Test and Evaluation program; has expertise in Battle Management, Command, Control, Communications, Computer, and Intelligence (BMC4I), testing, systems, and acquisition. She has a master's degree in Industrial and Systems Engineering and a bachelor's degree in Electrical and Computer Engineering.

To achieve operational dominance, warfighters need high-speed, interoperable systems that allow quick access and dynamic control of critically needed information. To facilitate the achievement of this objective and to support Army Transformation, the Future Combat Systems (FCS) program is envisioned as an umbrella system linking large numbers of manned and unmanned platforms into a lethal combat Force. FCS will serve as the foundation for developing a faster, lighter, smarter, and more lethal next-generation force. Space platforms play a vital role in the realization of this concept.

Achieving operational dominance will require the development and fielding of new technologies. One such Space technology with potential to support Army Transformation is Micro-Electro-Mechanical Systems (MEMS) or sometimes referred to as microsystems technology (MST). Generally, these systems include:

- Application-specific, -integrated micro-instruments (ASIMS)
- Micro-optical-electro-mechanical systems (MOEMS)
- MEMtronics (micromechanical structures)
- Nanoelectronics (atomic/molecular)
- MESO-technology (modules with many microstructures)
- μEngineering
- Smart structures[1]

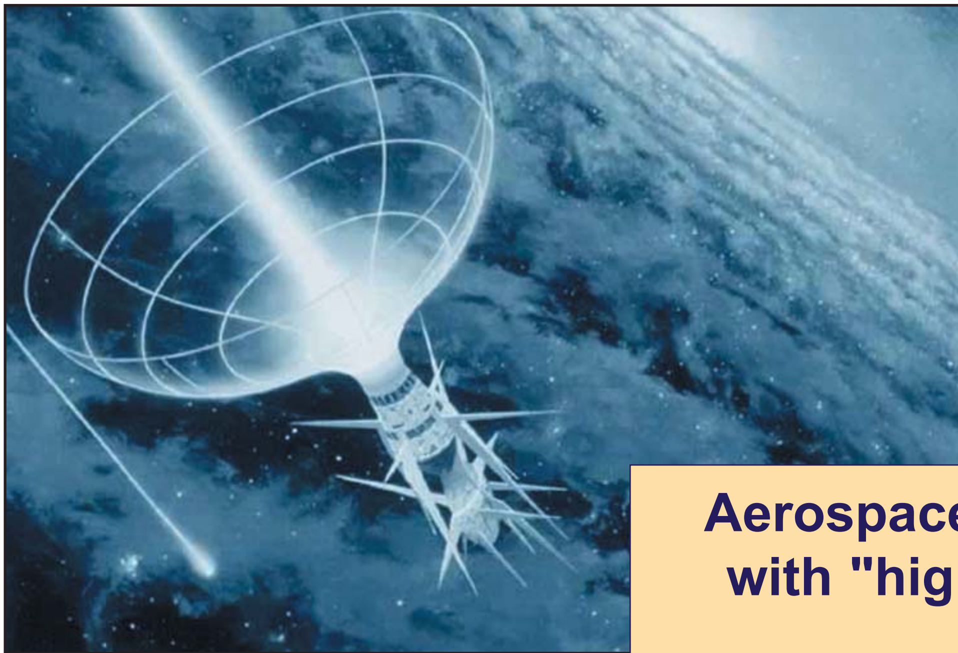
Since its emergence in the late 1980s, MEMS have developed into a billion dollar commercial market. MEMS are miniature devices that integrate actuators, sensors, and processors to form intelligent systems. Functional subsystems could be electronic, optical, mechanical, thermal, or fluidic. MEMS are characterized by their close relationship to integrated-circuit components both in terms of manufacturing techniques and their potential for integration with electronics. MEMS advantages include miniaturization (allowing distributed sensing and actuation coupled with redundancy), reduced fabrication cost (through the use of microelectronics processing technologies), and real-time control (allowing on-line active process control and health monitoring). MEMS can also control macro systems by using the natural physical amplification characteristics of the macro system. Other MEMS current realizable advantages, as well as potential promises, include small size (volume, mass, and weight) through miniaturization, low power consumption, increased functionality, modular design methodology, and low fabrication costs via mass production processes[2].

Numerous aerospace and military MEMS applications are currently under consideration. Examples include microjet arrays for flow control, inertial measurement units (IMUs) for inertial measurement and navigation, fuse/safety/arming for munitions, health monitoring of machinery, and telecommunications for pico satellites.

The MEMS aerospace applications are not without their barriers and challenges. Since failure to meet these challenges has more severe consequences for military than for commercial applications, progress has been slow in inserting many of the potential MEMS aerospace applications[4].

Implementation barriers and challenges include reliability, harsh environment, supply availability, obsolescence, packaging, manufacturing, lack of standards, and security aspects[5].

The telecommunications infrastructure across the world is expanding at a staggering rate in response to an ever-increasing demand for mobility, interconnectivity, and bandwidth. Fiber optic telecommunication systems have had a phenomenal growth in the number and size of manufacturers of optical components and devices. Initially, manufacturers relied on costly precision-based engineering to produce optical fiber connectors, splices,



Aerospace MEMS applications with "high-end" functionality

- Complete inertial and navigation units on a single chip.
- Inertial Measurement Units on a chip.
- Distributed sensing systems for monitoring, surveillance, and control.
- Miniature and integrated fluidic systems for instrumentation and biochemical sensors.
- Embedded sensors and actuators for maintenance and monitoring.
- Identification and tagging system using integrated micro-optical-mechanical MEMS.
- Smart structures and components.
- Microflow control.
- Fuze/safety and arming.
- Micropower and propulsion.
- Mass storage and novel display technologies.

and alignment structures. Such manufacturing techniques have, however, evolved to encompass micromachining as the basis for manufacturing low-cost, mass-produced components. Current micromachining methods in combination with integrated circuit-based processing techniques enable the fabrication of complex optical-electronic integrated circuits and micro-electro-mechanical alignment devices in production quantities[6].

In the context of military systems, the performance of MEMS devices must clearly satisfy the stringent specifications and environmental conditions expecting to be posed by such applications. These operational and environmental requirements will include electromagnetic compatibility and resilience to radiation, to high temperatures (including sharp cycles in excess of 150 °C), and to vibration and shock (up to 100,000g levels in force). In addition, the technologies should take into account the nonaccessibility after launch, in certain circumstances, which dictate the need for "first-time-right" qualification.

Packaging for military MEMS is therefore more critical than that for commercial application of the technology; even in commercial applications, it is regarded as a prime discriminator between commercial success and commercial failure. For commercial microsystems, packaging is said to account for 80 percent of the cost and 80 percent of the failures. Both percentages in a military environment are not likely to be lower and will in all probability be even higher.

Military MEMS applications are being addressed in the NATO Research and Technology Organization MEMS Task Group Applied Vehicle Technology-078. This group is assessing potential applications, determining technology status and research and development needs, discussing barriers for implementation, and developing insertion strategies. The task group saw the need to enhance user and MEMS supplier interactions and to increase MEMS awareness as enabling technology for several applications.

Army Transformation envisions a faster, lighter, smarter, and more lethal force. MEMS have the potential to not only support Space platforms but other platforms as well. As the concepts and technical capabilities of MEMS are realized, the use of MEMS will play a vital role in supporting the development of Space capabilities.

Footnotes:
1. El-Fatatry, Ayman. MEMS Aerospace Applications, Feb 2003, "Mechanical-Optical-~~Electro-Mechanical Systems (MOEMS)", pg 8-3~~
2. Ibid., pg 8-4.
3. Schadow, Klaus C. MEMS Aerospace Applications, Feb 2003, pg. I-20.
4. Ibid., pg 1-1, 1-2.
5. Ibid., pg I-23.
6. Ibid., pg 8-6